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(54) Title: VIDEO EDITING SYSTEMS
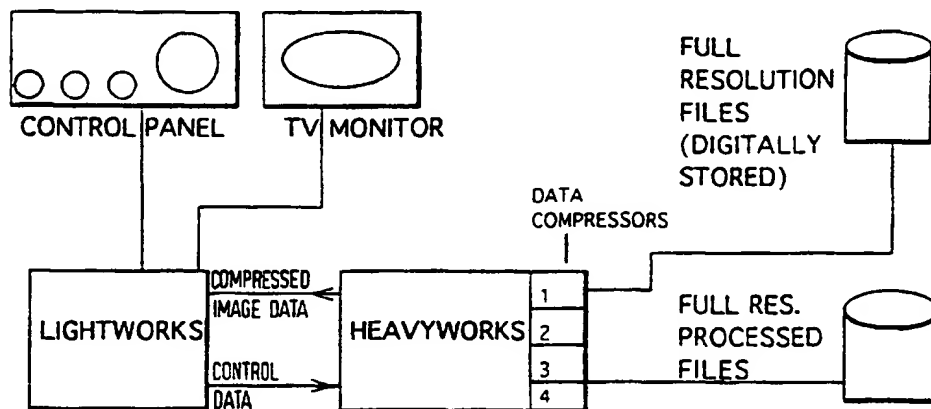
(57) Abstract

A system for editing video material comprises: (a) first digital data handling means for receiving and storing a sequence of image frames of relatively high quality; (b) means for converting the sequence of image frames into a corresponding sequence of image frames of relatively low quality; (c) second digital data handling means for receiving and storing the sequence of relatively low quality image frames; (d) operator input means associated with the second data handling means to enable manipulation of the sequence of relatively low quality image frames for edit decisions to be made; (e) communication means connected between the first and second data handling means, for communicating to the first data handling means edit decisions after manipulation of the frames in the second data handling means, substantially as such decisions are made; (f) means within the first data handling means for processing a first edit decision, and for manipulating the relatively high quality image frames accordingly, whilst the operator manipulates the relatively low quality frames in the second data handling means to make a second edit decision for communication to the first data handling means; and (g) means within the first data handling means for producing an output sequence of relatively high quality image frames in accordance with the first, second and any subsequent edit decisions communicated from the second data handling means.

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Video Editing Systems

This specification relates to video editing systems.

5

In the production of a work recorded on video media,
such as cinematographic films, video tapes, video discs
and so forth, editing is required. For example, shots
from several cameras will be cut and pasted together,

10   there will be fades from one shot to another, and so
forth.

In many current systems an edit decision list is
produced. This is a list setting out which clips from

15   which source are to be put together in what order to
make the final product. There will also be instructions
as to fading and so forth. In the case of films, an
editor will work from a cut-list, cutting specified
frames from appropriate reels of material and splicing

20   them together as required. Separate information will be
produced for "opticals" where optical printing is
needed, say, to combine frames for a fade. In the case
of video tapes it is known to supply the edit decision
list in the form of computer software to equipment which

25   will assemble a final video tape from various source
tapes.

The end result is an artistic work on cinematographic
film, video tape or other media, which is of "broadcast"

30   quality; that is, the quality and resolution of the
images is of the high standard appropriate to the
ultimate playback system, be it a projector in a cinema,
a tape to be broadcast by a television company, or a
tape to be used as a master from which domestic quality

35   tapes or.video discs are produced.

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It is inconvenient to work with broadcast quality media
in the production of the edit list itself and indeed one
object of using an edit list is that this is
subsequently applied to the broadcast quality material.
Accordingly, various "off line" systems have been
5   developed. In these, lower resolution versions of the
images are used by an editor to produce the edit
decision list. In one early proposal, an editor would
view and work with images from several video machines of
nearer domestic than broadcasting quality. The tapes on
10   these contained the same material - in terms of frames,
time codes etc. as the original broadcast quality
sources, but at a lower quality.

More recently, digital system have been developed. Such
15   systems produce low resolution, often data-compressed,
digitised representations of the original source
material. The digitised representations are stored in
fact access storage media such as magnetic disks,
optical disks and so forth, and are manipulated in
20   random access memory. In the case of cinematographic
films, it is first transcribed into suitable video media
by a telecine machine such as the Rank Cintel URSA or
BTS FDL 90, before the low resolution images are made.
Once the decisions have been made, the edit decision
25   list is produced and typically this is in the form of a
listing on a diskette. The diskette is used with an on-
line video editing system to produce the final broadcast
quality product. This process is known as conforming.

30   Such off-line systems have been produced by EMC, Avid
and OLE Limited (Lightworks).

It will be appreciated that the advantage of using lower
resolution images, perhaps compressed up to 100 times,
35   is that the power of the equipment (and thus its cost)
can be less, in terms of processing speed, memory,

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storage requirements and so forth. Nevertheless, the
image quality is still good enough for editors to work
with.

Whilst such a two stage process is to some extent
5   inconvenient, in terms of having to produce e.g. a
diskette for an on line editing machine, it would be
prohibitively expensive for all editing to be carried
out on currently available on line editors. Time is
also a factor, and high resolution images take longer to
10   manipulate than the lower resolution images used in off
line editing systems.

The problems are increasing as there are moves towards
even higher resolution media. For example, High
15   Definition Television ("HDTV") is planned. By way of
example, a frame of material in an off line system - of
low resolution and compressed - may occupy 20 to 50 Kb.
At conventional broadcast quality resolution the frame
may occupy 1 Mb of storage space. With HDTV material,
20   it would occupy 5 Mb of space.

It is also proposed to use digitised film images at full
cine resolution of eg. 3000 lines by 4000 pixels. Such
images can be input into a digital system, manipulated,
25   and then output at full resolution.

Such high resolution equipment is considerably more
expensive than existing on line editing equipment and it
is not cost effective to use it for routine editing and
30   making edit decisions.

Accordingly, an object of the invention disclosed herein
is to retain the cost effectiveness of off line editing
whilst facilitating the production of the broadcast
35   quality product.

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Viewed from one aspect an invention disclosed herein
comprises a system for editing video material
comprising:

(a) first digital data handling means for receiving and
5   storing a sequence of image frames of relatively
       high quality;

(b) means for converting the sequence of image frames
       into a corresponding sequence of image frames of
       relatively low quality;

10 (c) second digital data handling means for receiving
       and storing the sequence of relatively low quality
       image frames;

(d) operator input means associated with the second
       data handling means to enable manipulation of the
15   sequence of relatively low quality image frames for
       edit decisions to be made;

(e) communication means connected between the first and
       second data handling means, for communicating to
       the first data handling means edit decisions after
20   manipulation of the frames in the second data
       handling means, substantially as such decisions are
       made;

(f) means within the first data handling means for
       processing a first edit decision, and for
25   manipulating the relatively high quality image
       frames accordingly, whilst the operator manipulates
       the relatively low quality frames in the second
       data handling means to make a second edit decision
       for communication to the first data handling means;
30   and

(g) means within the first data handling means for
       producing an output sequence of relatively high
       quality image frames in accordance with the first,
       second and any subsequent edit decisions
35   communicated from the second data handling means.

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Thus, whilst the operator is spending time manipulating
frames and e.g. assessing artistic possibilities before
making an edit decision, the results of earlier
decisions have been transmitted to the first data
handling means. This then processes the decisions and
5   applies them to the high quality images. Processing
time in the first data handling means is used more
effectively, and the intention is that shortly after the
last edit decision has been made, the high quality
output material will be available.
10

The material which the operator views and works with in
the second data handling means is, in terms of artistic
content, identical to that in the first data handling
means. All of the same frames are available and coded
15   to enable correlation with the frames in the first data
handling means. The difference is that the images are
of lower quality.

The relatively high quality image frames which the first
20   data handling means processes, may be of conventional
broadcast quality or of higher HDTV quality, or even of
film resolution. In practice they may be slightly less
than full broadcast quality for some applications.

25   In practice, in accordance with normal video editing
procedures, a number of sequences will be held in the
data handling means, and decisions made concerning the
selection of frames. Generally, selection will be of a
number of frames, i.e. a shorter clip from a complete
30   sequence loaded in.

Depending upon the nature of the editing carried out by
the operator, and upon the speed of the first data
handling means, it is possible that the latter may be in
35   an idle state between acting upon edit decisions.

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It is therefore proposed that the first data handling means be in communication with a plurality of second data handling means. These may be operating on the same project, or on completely separate projects.

5   In preferred arrangements, the first data handling means receives high quality source material, and produces the lower quality material which is provided to the second data handling means. Thus the first data handling means preferably includes means for reducing the resolution of 10   the images and/or compressing the data, for supply to the second data handling means.

The first data handling means must itself process images of high quality. Nevertheless a certain amount of 15   compression is possible without adverse degradation of image quality, say 8 or 10:1. The resolution should be maintained.

Typically, therefore, images will be reduced in 20   resolution - for example, by omitting alternate lines or by more sophisticated technique - and compressed by say 20:1 or more for supplying to the second data handling means. In the first data handling means the resolution of the source material will be maintained but 25   compression of 8 to 10:1 may be used. This will assist operation but without visible degradation of picture quality.

The first and second data handling means will typically 30   differ in terms of e.g. the memory, storage space, processor speed and so forth. The first data handling means will have increased, typically by four times, bandwidth. However, a common processor could be used. Indeed, the two data handling means could be combined in 35   the same physical unit. The first data handling means could be used as a stand alone system, having for

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example sufficient power to handle four pictures at
once, at full speed. These will be of lower resolution,
perhaps similar or slightly better quality than those of
the second data handling means.

5   They appear on the graphics screen as usual, but also on
4 separate video outputs. This opens the way to on-the-
fly editing of multicamera material, as if working live
or with multiple tape machines, but with all the
advantages of random-access. One possibility is to take
10   an EDL based on a live cut, import it, and then quickly
improve it until it is perfect. This will be for sports
and the like. The machine may have a fifth video
output, so that the edit can be watched as it is built.
Further aspects of "live editing" will be discussed
15   below.

The machine can also work with much more sound
simultaneously. It may have at least 8 real channels of
production-quality sound, all playable at once. This
20   can be upgraded to 16 real channels. There is a
distinction between real channels and the number of
tracks that can be laid - so-called virtual tracks.
These, of course, have no real limits.

25   As discussed above, the machine can play pictures that
are much less compressed and therefore of much higher
quality. These pictures are of full horizontal
resolution, and 50/60 fields. In practice they will be
of a quality good enough for some on-line uses, such as
30   news and some corporate work. They may not be full
broadcast quality.

It is necessary to understand that the way in which
large mounts of picture can be put into a computer is to
35   compress them. Beyond 2-1 compression, the process is
no longer lossless. That is, one cannot go back to

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exactly where one started. It then becomes a question
of how far to go without noticing the losses. Current
consensus seems to be that beyond 3-1 compression there
is no longer a system that remains unnoticeable through
repeated round-trips, such as will be experienced when
5   adding effects etc. For pure delivery of finished
product one can probably go up to 6 or 8-1 before
noticing much at all, and standards are evolving for
doing that. However, editing is not delivery, and does
require round-trips.
10

For full broadcast quality, one cannot compress more
than, say, 4-1, which is about 6 Mb/second or 3 minute
quality. This is 20 Gb/hour (7 disks). It would be
very expensive to construct such a machine in terms of
15   storage.

A more practical machine will sustain a single picture
or two pictures at 2 Mb/second, plus a great deal of
sound. This is equivalent to about 9-minute quality,
20   and looks good.

All of this requires extremely large amounts of disk
storage. About 150 Gb may be required on-line, which
equates to 15-250 hours depending on quality.
25

There are also disclosed herein improvements in data
compression techniques. Whilst these are of particular
use in the context of the video editing system described
above, they will be of use in other contexts only.
30

Techniques are known for compression techniques for the
digital files that describe images. These are well
documented in such sources as 'Digital Image Processing'
by William K Pratt, published by John Wiley & Sons, ISBN
35   0-471-01888-0.

These techniques include the simpler methods such as run
length coding, which will give a compression ratio of
typically around 3:1. Whilst such methods are of some
use, it is often desirable to have a system that will
give a compression ratio which is much higher. One such
5   method is the scheme referred to as 'JPEG', being the
method established by the Joint Photo-Interpreters
Experts Group. This method is a highly mathematical
technique involving the two-dimensional discrete Cosine
transform, as explained in "Digital Imaging Processing"
10   pages 242-247. The JPEG technique is currently a Draft
International Standard for the coding of Continuous Tone
Still Images, ISO DIS 10918, and offers users
compression ratios of up to 50:1 with little image
degradation. The principle of JPEG is as follows:-
15

1.   Divide the image up into regular tiles. Each tile
        is either 8x8 pixels or 16x16 pixels.

2.   Take the two-dimensioned DCT of each block.
20   Mathematically this is implemented by taking the
        DCT of each of the lines of eight (or sixteen)
        pixels in each of the eight (or sixteen) lines per
        block, writing the answer back into that address of
        the block, and repeating the operation on each of
25   the columns. This is possible because the 2-D DCT
        has a mathematical property known as separability.
        At this point no compression has taken place, but
        the data has been decorrelated.

30   3.   Each block then has its energy assessed. This can
        be done in many ways, such as summing the squares
        of the 2nd to 64th coefficient in the block.

        4.   Classification then takes place dependant on
35   energy. Blocks are then labelled into High,
        Medium, and Low energy, with various classes

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between.

5.   Dependant on which class each block is in, it is
      thresholded (ie. an offset is removed from each
      element), and quantised (ie. it is represented as a
5   nearest multiple of a constant.

6.   The remaining data (which will contain a large
      number of zeroes) is then run length, or Huffman
      coded to reduce the data even further.

10
7.   The remaining bits are then 'packeted' with a
      header and information on the energy class. Error
      correction is quite often added at this stage.

15   8.   Decoding is the reverse of coding.

      A further scheme is MPEG, the Motion Picture Experts
      Group. This is described in Draft International
      Standard ISO/TEC DIS 11172. This offers potentially
20   higher compression ratios, by comparing subsequent
      frames of a motion picture sequence.

      For most digital imaging, it is usual to have 'scan
      lines'. The Image is represented as a sequential
25   sequence of values, describing the intensity (or
      brightness) of picture elements (pixels). Thus the data
      structure consists of the brightness value of the first
      pixel in the first line, followed by the second pixel of
      the first line, and then subsequent pixels of the first
30   line through to the last pixel of the first line. Then
      the data structure contains the brightness value of the
      first pixel of the second line through to the last pixel
      of the second line. This is continued through to the
      last line of the image. This is a 'normal' image data
35   structure.

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It is, however, sometimes necessary to describe a given image in more than one resolution. Such an example may be where a very high resolution image is to be eventually created, such as a full page colour picture for a high quality magazine. This picture may consist

5   of, say 5000 lines of 4000 picture elements each. This resolution ·is far higher than can easily be displayed on a colour monitor, such devices being typically less than 1000 lines by 1500 pixels. Thus at a 'one-to-one' resolution only a small part of the final image can be

10   displayed. A typical solution to this dilemma is to store a reduced resolution or subsampled version of the final image which is the same resolution as the colour monitor.

15   An object of a further invention disclosed herein is the provision of a data compression technique which is versatile and of particular, but not exclusive, benefit in a video editing system as described above.

20   According to one aspect of this further invention there is provided a method for compressing digitised image data in data handling means, wherein:-

     (a)   a plurality of different image resolutions are
25   provided from given source material; and
     (b)   data in respect of different respective image
           resolutions is compressed by different respective
           amounts.

30   In the preferred arrangement, higher resolution images may be compressed by lower amounts.

     Thus, for example there may be a "pyramidal" or "Laplacian" structure. At the bottom may be a high
35   resolution image, for example corresponding to broadcast quality source material. This will be compressed by a

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relatively small amount, such as 8 or 10:1, to minimise
picture degradation. Higher up the pyramid there will
be a picture at lower resolution, for example for use in
the video editing system described above. This will be
compressed by a greater amount, and for example 20:1.

5

At the top of the "theoretical" data structure there is
one singular value, describing the overall average
brightness of the picture. The resolution level below
this would be, say 2x2 rather than 1x1. Below that, the

10   resolution level will be 4x4 and so forth. Instead of
describing a complete level, the difference could be
stored between the previous level and the predicted
level, predicted by linear interpolation.

15   Different techniques could be used at different levels.
Thus, for example, at a level for use as the relatively
low quality image, used in the editing system described
earlier, the resolution may be set by omitting alternate
lines. By contrast at a level for produced HDTV quality

20   images the resolution may be set by averaging out groups
of say four pixels.

Preferably, a plurality of compression operations are
carried on by parallel compressors. It is known, for

25   example, to use parallel compressors to compress
different parts of a particular image. For example four
compressions could be used, each for a quarter of the
image. By contrast, in preferred embodiments of the
present invention parallel processing technique are

30   carried out on different respective resolution levels.
Thus one processor may handle certain low resolution
levels whilst one or more can simultaneously handle
higher resolution levels. At the lower resolution, a
single processor may be able to handle a number of

35   levels in the time that it takes one, two or more to
handle a single high resolution level.

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An advantage of this arrangement is that when a
compressed image is required, all desired resolutions
can be obtained simultaneously.

Thus in the context of the video editing system
5   described earlier, source material may be taken in to
the first data handling means. There, parallel
processors will work on (a) high resolution, mildly
compressed files for use in the first data handling
means; and (b) lower resolution more highly compressed
10   files for use in the second data handling means.

It will be appreciated that the compression and other
techniques described herein may be used in systems other
than the editing of films, video tapes and the like.
15

Figure 1 shows diagrammatically apparatus in accordance
with the invention. The "Heavyworks" machine represents
the first data handling means which may for example be
an EISA system with a 66 MHz Intel 486 DX processor or a
20   586 processor, and say 16 Mb or more of RAM. The
"Lightworks" machine represents the second data handling
means. This may be an ISA system with a 33 MHz Intel
486 DX processor, again with 16 Mb or more of RAM. This
unit is provided with a control panel and a monitor.
25   The "Heavyworks" unit takes in full resolution digitally
stored files, and provides compressed image data for the
"Lightworks" unit where edit decisions are made.
Control data is then passed back to enable processing of
full resolution files.
30

The procedure of the communication flow can be
considered by the process that the operator would go
through in a real job. It is as follows:-

35   1.   All material that may be required in a given job
will be 'digitised' into the Heavyworks unit.

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2. At the Lightworks terminals, the operator will
    require a 'clip list' from the Heavyworks unit.
    This will be the list of all clips available at the
    Heavyworks unit.

5   3. From this list, the operator will request that
    several of these clips are made available for him
    at his Lightworks terminal.

4. This request will be passed over the link between
10 the two machines, and the Heavyworks unit will
    process the requested clips into 'Lightworks' form.
    This is a lower quality higher data compressed
    form. They will then be transmitted over the link
    to the lightworks terminal.

15
5. Having received the clips, the operator will now
    perform the non linear editing functions necessary
    to form a complete work. As he makes each
    decision, this decision is communicated over the
20 link to the Heavyworks.

6. During the process of the construction of a low
    quality version of the final work on the
    lightworks, the Heavyworks unit will be continually
25 creating a high quality representation of this work
    with its own high quality digitised files. It is
    acknowledged that this process is not 100%
    efficient, as the operator is likely to change his
    mind several times in the artistic process of
30 creating a completed work, and this will involve
    several unnecessary conforming steps. However, it
    has the advantage of minimising the time between
    the operator finishing the work on the lightworks
    and the work being available on the heavyworks
35 station in 'on-line' quality.

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As regards the hardware of the link, there are several
suitable communication media. The first is the Bit
Parallel form of Recommendation 601 of the CCIR. The
second is the bit serial form of the above. The third
is using the SCSI protocol (Small Computer Systems

5   Interface). This is usually the protocol small
computers for talking to their discs, but a 'dual
ported' version exists in which there can be two
'masters', which could be the Lightworks and Heavyworks
units respectively. A fourth format of the

10   communication media could be the FDDI (Fibre Distributed
Data Interchange). This is the standard for Fibre
Optics systems. Yet another standard could be the
'Ethernet' protocol, of transmitting computer to
computer communications over Co-Axial cable.

15

Figure 2(a) shows how conventional parallel data
compression works. Each quarter of an image is
compressed by its own compressor. Figure 2b shows a
pyramidal data structure, with different levels covering

20   different resolution. At the top is a single pixel,
whose value is the average of the entire image. Lower
down are higher resolution images. Figure 2c shows how
compressors can be used in parallel on these different
levels. Thus three compressors work in parallel. One

25   handles the top two layers, one the next two, and one
the bottom. As noted earlier, the degree of compression
for the lower layers - that are the highest resolution -
may be more gentle than for higher levels.
Nevertheless, the same degrees of compression could be

30   applied and the concept of using parallel compressors in
this way is advantageous.

Thus according to an aspect of an invention disclosed
herein, there is provided a method for compressing

35   digitised image data in data handling means wherein:-

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(a)   a plurality of levels of different image resolution
      are provided from given source material; and

(b)   a plurality of data compression means act in
      parallel on respective levels.

5

There has now also been developed an improved system for
generating the levels of different image resolutions.
Starting at the highest resolution, it is necessary to
store data in respect of that resolution, and in respect
of the next level - i.e. the lower resolution image to
be processed in the "Lightworks" unit. This lower
resolution image may have one quarter of the pixels of
the first level, this being achieved by averaging out
the value of four pixels in the first level. Thus, if
four adjacent pixels forming a square in the first level
have values A, B, C, D, then the corresponding single
pixel in the level above will have the value
$(A+B+C+D)/4$.

10

15

20   Each value requires 8 bits and thus 40 bits are required
to store data for this part of the image, in both
resolutions.

According to an improved method, less data needs to be
25   stored. The value of the single pixel of the second
level is still stored as $(A+B+C+D)/4$ and requires 8
bits. There are then stored three difference
expressions, namely:-

30            $(A+B+C-D)/4$
              $(A+B-C+D)/4$
              $(A-B+C+D)/4$

From these it is possible, using simultaneous equation
35   techniques, to derive the values of A, B, C and D.

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The three difference equations require 9 bits (8 for the
number and 1 for the sign). Thus the total data to be
stored is 8 bits plus 3 x 9 bits, i.e. 35 bits. This is
a saving of 5 bits over storing the pixel values
separately.

5

Over an entire image there is a significant saving in
the amount of data to be stored.

There is still immediate access to the lower resolution
10   values. There is a delay in access to the higher
resolution values as these have to be derived. However,
that is acceptable in the context of the video editing
systems described herein.

15   Thus, according to an aspect of an invention disclosed
herein, there is provided a method of storing data
relating to an image, comprising the steps of:-

(a)   Providing an image as a series of pixels, at a
20   first resolution;

(b)   Storing data relating to a second, lower resolution
version of the image in which the value of each
pixel is calculated as an average of a number of
25   associated pixels at the first resolution; and

(c)   Storing data from which the values of the
associated pixels can be calculated by a
simultaneous equation technique.

30

As will be noted from the description earlier, the
"Heavyworks" unit is a powerful unit for processing
video signals, and is capable of handling a number of
video inputs, for example four or more, and processing
35   them substantially in real time. This makes it possible
to use the system for switching and mixing video signals

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in what is essentially a "live" context. This is of
particular interest in areas where there are currently
problems, such as effective coverage of live sports
events using multi-camera shoots.

5   It is useful to consider the normal way that multi-
camera shoots are carried out. Multi-camera shoots are
common for sports occasions, such as motor racing, where
it is desirable to have a view of the race from
different points around the track, and for similar
10   reasons such other sports as tennis and football.
Multi-camera work is also used for situation comedies,
where the camera cuts contribute to the comedy. In
these shoots, all of the cameras (typically three or
four) are 'running' all of the time. For 'live' events,
15   the program producer will be looking at a bank of TV
monitors. Each of these monitors will be displaying the
feed from one of the cameras. Based on the multiplicity
of images presented to him, the program producer will
typically give the command to 'cut' from broadcasting
20   the signal coming in from, say, camera 1 to say, camera
3. This is a very demanding and exacting requirement
from a person, and due to the unpredictable nature of
sporting events, can result in the transmission to the
viewer of sub-optimal quality coverage of an event. A
25   typical example of this is in coverage of a motor race.
The producer may command the production assistant to
'cut' from a camera shot where the racing cars are
passing one camera, to another camera around the track.
The producer may wish to do this to obtain the shot of
30   the racing cars coming round a corner into the distant
view of the next camera. Just after the cut has
happened, two of the cars may crash into each other.
The producer is now faced with a problem. Because of
the real time nature of the race and broadcast, he has
35   missed the crash. The best he can do is to cut back to
the previous camera, and see the debris of the crash.

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An alternative way of covering such a sporting event is
to record the whole event as seen from each camera.
After the event has finished, the resulting videotapes
can be edited together, to produce a finished
production. This production has the advantage that the
5   producer can 'look ahead' and make sure he does not miss
anything. Conversely, if he does miss anything, being a
non-real time process, he has time to re-edit. This
editing process can either take place in a conventional
'on-line' suite, where the broadcast quality images are
10   present, or on a conventional 'non-linear' editing suite
or in an improved system as described earlier in this
specification.

All of these processes of compiling a finished program
15   take time. To produce a finished one hour coverage
using conventional systems will typically take two
hours. Thus if a sporting event takes place from mid-
day to one o'clock, then the compiling can start at one,
and be finished by three o'clock. Because of the
20   uncertain time taken to compile the finished cut, it is
unlikely that a broadcast slot before, say, five o'clock
will be scheduled. Thus the program seen by the viewer
in his home will be at least five hours old!

25   A major disadvantage of this process is that it does not
result in a 'live' performance. Recorded (non-live)
sport has a far lower financial value than lives sports
coverage.

30   It would be possible to provide each camera, with an
"instant replay" system, so that if a shot is missed
then a replay can be obtained from the system associated
with the camera which was on the shot. Such a system is
used for some of the cameras in, for example, the
35   coverage of a football match. After a goal has been
scored, a replay may be shown from a camera best

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situated to show the incident. In some cases a number
of replays may be shown. However, it is expensive to
provide instant replay systems for each camera, and
there is still the problem that the initial live
pictures may not have been the best shots. Furthermore,
5   whilst a replay is being shown another incident may
occur, and live coverage of this will be missed.

In an ideal system therefore, the best shots would be
shown live.

10

An object of a further invention disclosed herein is to
enable the quality of the 'recorded' coverage to be
available together with the 'immediacy' of the live
work.

15

According to one aspect of a further invention disclosed
herein, there is provided a method of providing a video
output comprising material which is mixed from a
plurality of input sources, comprising the steps of:-

20

(a)   Feeding the input signals from each source to both
       a respective input buffer and to a switching and/or
       mixing unit;

25   (b)   Switching and/or mixing the input signals to
       provide an initial video output;

(c)   Feeding the initial video output into an output
       delay buffer;

30

(d)   Providing a final video output from the output
       delay buffer after a predetermined delay;

(e)   Monitoring the initial video output; and

35

(f)   In the event that it is desired to alter the nature

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of the final video output, replacing material in
the output buffer by alternative material stored in
one of the input buffers.

Thus, in the simplest case there would be two input
5   sources, ie. video cameras, feeding live material. This
goes to a switching/mixing unit where the shots are
combined as desired and an initial output is provided.
The live material is also supplied to two input buffers,
one associated with each camera. Here, it is stored
10   temporarily - for example for one minute, in case it is
required again at some time in that period. The
programme producer carries out various switching and
mixing operations and monitors the initial output. It
is decided that a shot from camera two, say, is required
15   in place of a shot from camera one. Then a command is
issued. The system then locates the appropriate shot in
the input buffer associated with camera two, locates the
unwanted shot in the output buffer, and effects the
substitution. Thus, the final output consists of the
20   required shots.

Of course, the final output is subject to the
predetermined delay, which is necessary for the
technique to be operated, but this is not a problem in
25   practice. The delay may be, for example, 1 minute.
This is close enough to "live" for all practical
purposes. The output will normally be fed into a
broadcasting system via the usual routes such as
microwave links, land lines etc. Of course the output
30   could be recorded.

Viewed from another aspect, there is disclosed herein
apparatus for mixing video signals comprising:-

35   (a) A plurality of signal inputs;

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(b)   A plurality of input signal storage means, one
       associated with each input;

(c)   Means for mixing signals received from the inputs
       and for producing initial output signals;

5

(d)   A delay buffer for receiving the initial output
       signals and producing final output signals after a
       predetermined delay;

10   (e)   Means for retrieving signals stored in the input
       storage means; and

(f)   Means for replacing signals in the delay buffer by
       signals retrieved from the input storage means.

15

In a practical example, the basis of the hardware used
is the 'Heavyworks' platform. This is a broad bandwidth
video channel product. In one implementation it can be
thought of as a four channel input, storage, and four
20   channel output device, together with storage. The
architecture of the 'Heavyworks' unit is such that it
can record or 'buffer' digitally the incoming signals
from four or more cameras.

25   This invention is put into effect by the use of the
storage elements within the Heavyworks product. The
intention is to have the advantage of being able to
'look ahead' to what is going to happen, without losing
the 'live feel' of the broadcast. This can be done by
30   storing all channels for say, one minute, in the
Heavyworks. This time is sufficiently small that the
live 'feel' will not be lost. Indeed this amount of
delay is so small it will be indiscernible. This one
minute delay gives chance to get the cuts correct.
35   Thus, if a bad cut (as in the car racing example above)
happens, then during the one minute delay between the

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event 'happening' and it going out on air, the operator
has a second (or even third) chance to provide a
desirable cut. All of the non-linear editing facilities
are available to the operator, but at 'on-line' quality
and without the loss of the live 'feel'.

5

A second feature of the system is that pre-programmed
cuts are possible. Consider a game of tennis. In such
a sport it may be desirable to cut between two cameras,
one covering each player. In such a sport it is

10   predictable that a volley will take an average given
time, such as two seconds. It may therefore be possible
to set the 'cutting rate' between cameras to this time
period. This will be a 'best guess' for the cuts, but
will not be correct for every volley. For example when

15   a player misses a shot, it may be desirable to keep the
camera on him. Thus for 'normal' volleys the 'autocut'
will be correct, and only in exceptional cases does the
operator need to edit or 'override' the autocut.
Another such 'autocut' facility could be for the

20   recording of a situation comedy. From the script, it is
possible to estimate the length of each piece of
material, and therefore the 'cut' points. Because of
the minor timing unpredictability of humans, there will
be a few occasions in which the 'autocut' does not

25   happen at the optimal time. These sub-optimal cuts can
be adjusted during the (nominal) one minute buffer
period. This buffer period may be adjusted, depending
on the amount of storage available in the Heavyworks
system, the number of cameras used, and the complexity

30   of the event to be recorded.

Figure 3 contains an overall architecture diagram of the
proposed system.

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Claims

1. A system for editing video material comprising:

(a) first digital data handling means for receiving and storing a sequence of image frames of relatively high quality;

(b) means for converting the sequence of image frames into a corresponding sequence of image frames of relatively low quality;

(c) second digital data handling means for receiving and storing the sequence of relatively low quality image frames;

(d) operator input means associated with the second data handling means to enable manipulation of the sequence of relatively low quality image frames for edit decisions to be made;

(e) communication means connected between the first and second data handling means, for communicating to the first data handling means edit decisions after manipulation of the frames in the second data handling means, substantially as such decisions are made;

(f) means within the first data handling means for processing a first edit decision, and for manipulating the relatively high quality image frames accordingly, whilst the operator manipulates the relatively low quality frames in the second data handling means to make a second edit decision for communication to the first data handling means; and

(g) means within the first data handling means for producing an output sequence of relatively high quality image frames in accordance with the first, second and any subsequent edit decisions communicated from the second data handling means.

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2.   A system as claimed in claim 1, wherein the first
data handling means preferably includes means for
reducing the resolution of the images and/or compressing
the data, for supply to the second data handling means.

5   3.   A system as claimed in claim 2, wherein
     (a)   a plurality of different image resolutions are
            provided from given source material; and
     (b)   data in respect of different respective image
            resolutions is compressed by different respective
10   amounts.

4.   A system as claimed in claim 3, wherein, in the
first data handling means, parallel processors will work
on (a) high resolution, mildly compressed files for use
15   in the first data handling means; and (b) lower
resolution more highly compressed files for use in the
second data handling means.

5.   A system as claimed in claim 2, 3 or 4, comprising
20   the steps of:-

     (a)   Providing an image as a series of pixels, at a
            first resolution;

25   (b)   Storing data relating to a second, lower resolution
            version of the image in which the value of each
            pixel is calculated as an average of a number of
            associated pixels at the first resolution; and

30   (c)   Storing data from which the values of the
            associated pixels can be calculated by a
            simultaneous equation technique.

6.   A method for compressing digitised image data in
35   data handling means, wherein:-

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(a) a plurality of different image resolutions are
     provided from given source material; and

(b) data in respect of different respective image
     resolutions is compressed by different respective
     amounts.

7.   A method of storing data relating to an image,
comprising the steps of:-

(a) Providing an image as a series of pixels, at a
     first resolution;

(b) Storing data relating to a second, lower resolution
     version of the image in which the value of each
     pixel is calculated as an average of a number of
     associated pixels at the first resolution; and

(c) Storing data from which the values of the
     associated pixels can be calculated by a
     simultaneous equation technique.

8.   A method of providing a video output comprising
material which is mixed from a plurality of input
sources, comprising the steps of:-

(a) Feeding the input signals from each source to both
     a respective input buffer and to a switching and/or
     mixing unit;

(b) Switching and/or mixing the input signals to
     provide an initial video output;

(c) Feeding the initial video output into an output
     delay buffer;

(d) Providing a final video output from the output
     delay buffer after a predetermined delay;

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(e)   Monitoring the initial video output; and

(f)   In the event that it is desired to alter the nature
      of the final video output, replacing material in
      the output buffer by alternative material stored in
5   one of the input buffers.

9.   Apparatus for mixing video signals comprising:-

(a)   A plurality of signal inputs;
10

(b)   A plurality of input signal storage means, one
      associated with each input;

(c)   Means for mixing signals received from the inputs
15   and for producing initial output signals;

(d)   A delay buffer for receiving the initial output
      signals and producing final output signals after a
      predetermined delay;
20

(e)   Means for retrieving signals stored in the input
      storage means; and

(f)   Means for replacing signals in the delay buffer by
25   signals retrieved from the input storage means.
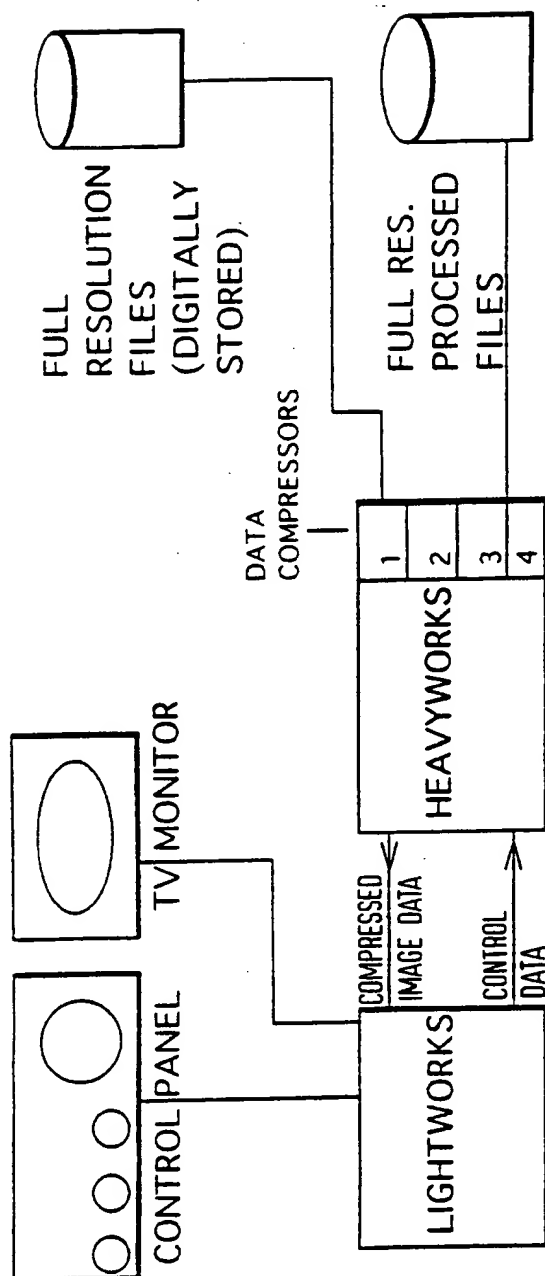
FIG.1
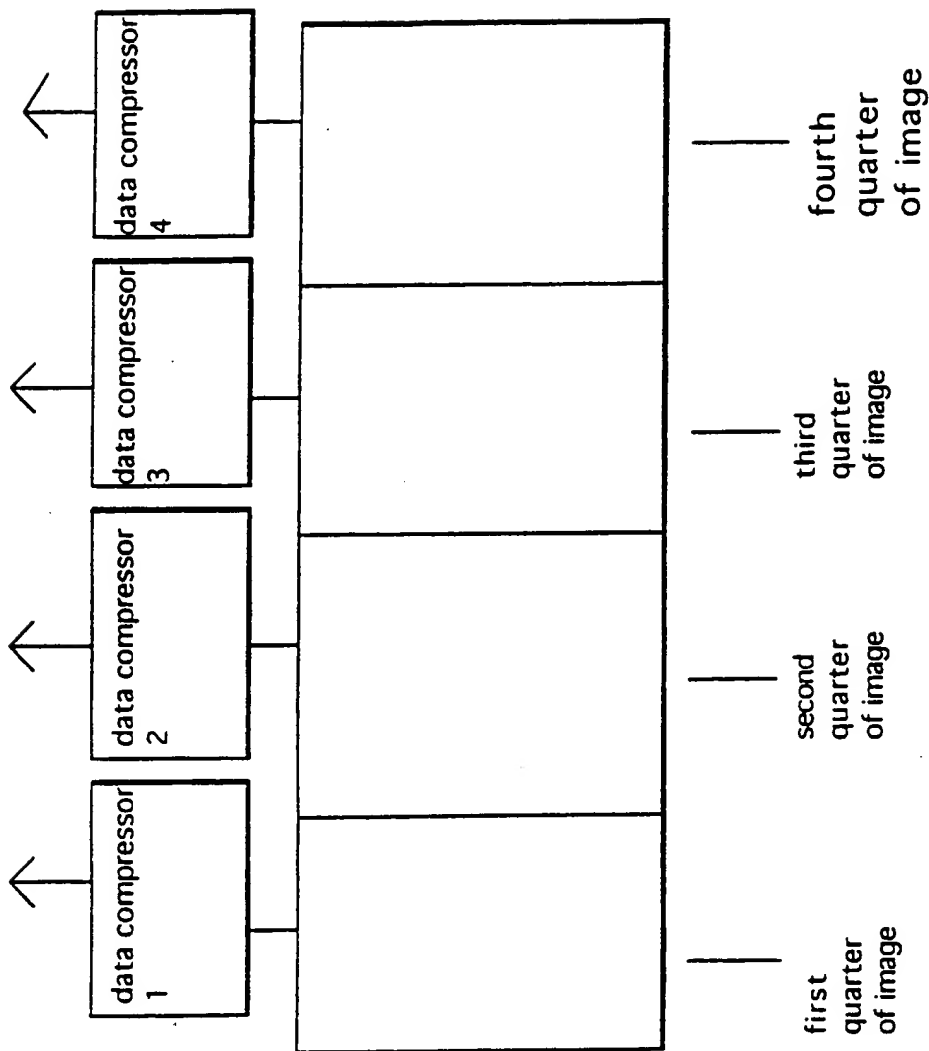
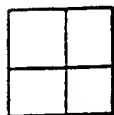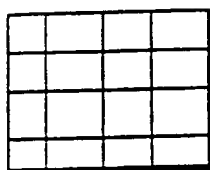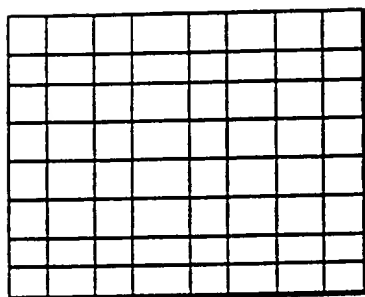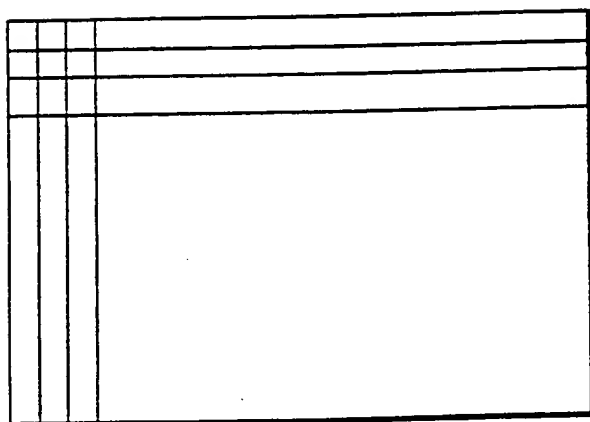FIG.2a

1X1 SIDE LENGTH 2 POWER 0=1 NO PIXELS=1

2X2 SIDE LENGTH 2 POWER 1=2 NO PIXELS=4

4X4 SIDE LENGTH 2 POWER 2=4 NO PIXELS=16

8X8 SIDE LENGTH 2 POWER 3=8 NO PIXELS=64

2 POWER N X 2 POWER N

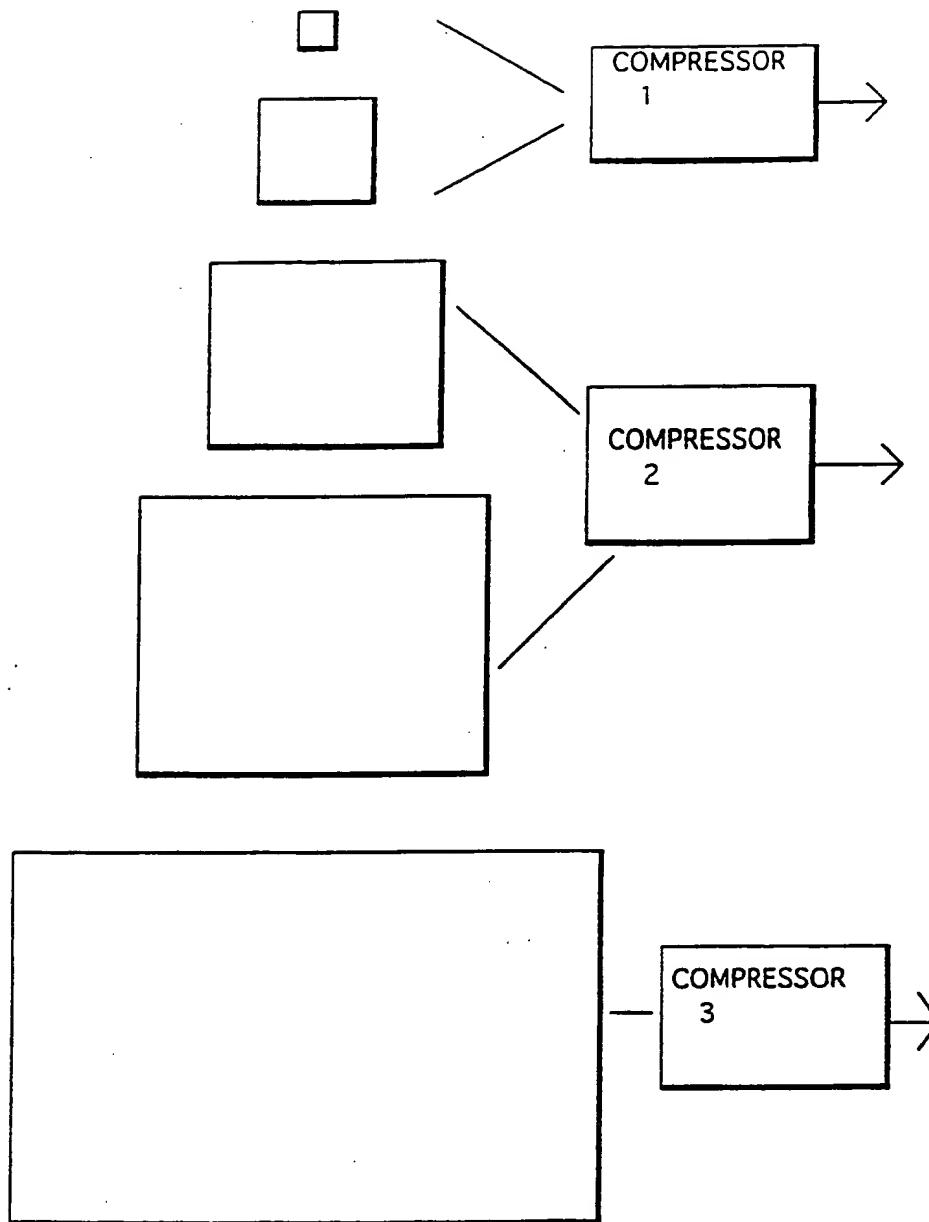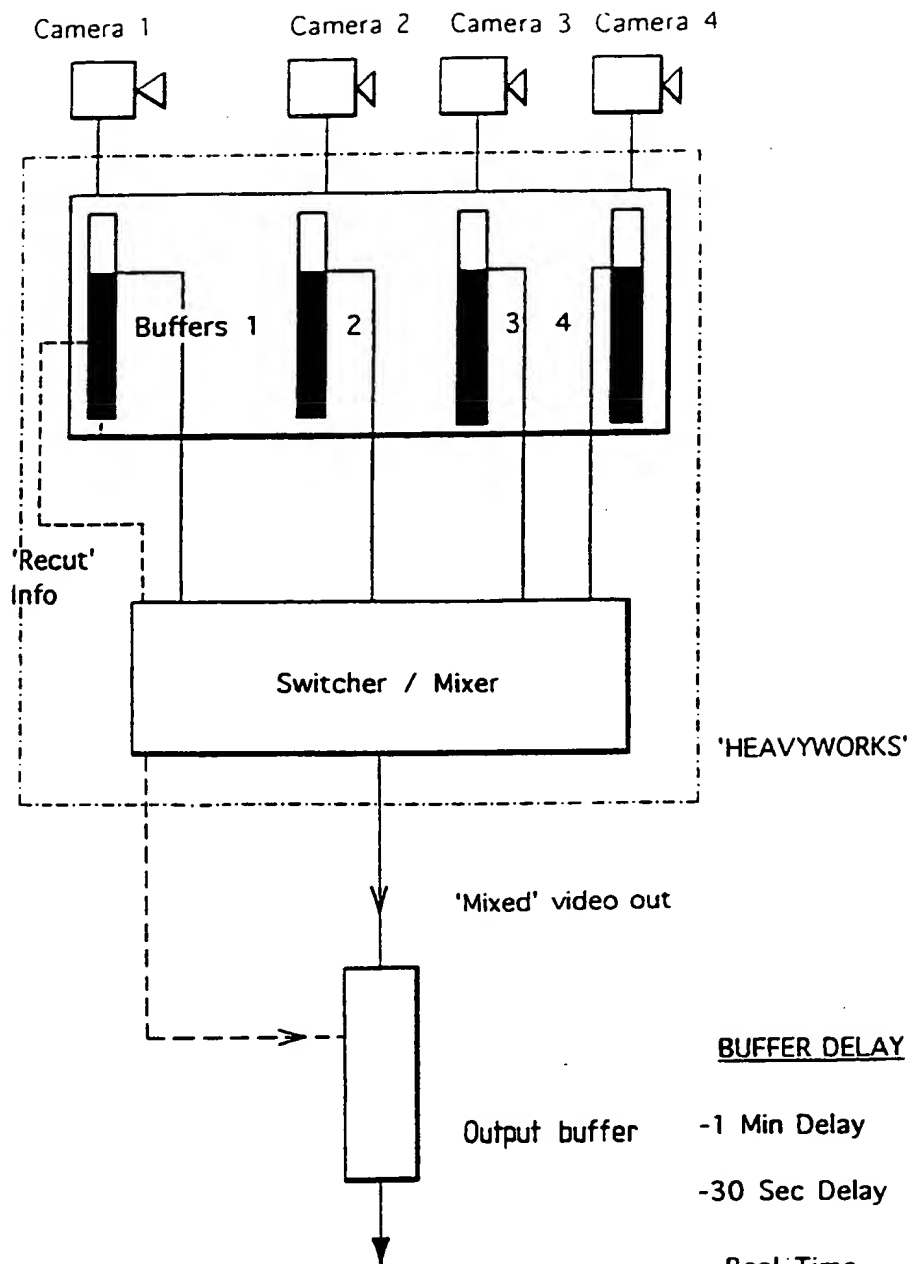SIDE LENGTH = 2 POWER N NO PIXELS=2 POWER 2N

FIG.2b

FIG.2c

Camera 1   Camera 2   Camera 3 Camera 4

Buffers 1   2   3   4

'Recut'
Info

Switcher / Mixer

'HEAVYWORKS'

'Mixed' video out

BUFFER DELAY

Output buffer   -1 Min Delay

-30 Sec Delay

- Real Time

FIG.3